Fruit Notes

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Fruit Notes

Editors: Wesley R. Autio & Winfred P. Cowgill, Jr.

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Cover: Mature Honeycrisp/B.9 from Van Well nursery trained as tall spindles at Phillips Farms, Milford, NJ. Photo Credit: Win Cowgill.

Double-notching Whip Apple Trees at Bud Break Is Effective at Promoting Branching

Jon Clements
University of Massachusetts Extension

Nursery apple trees that arrive as unbranched, so-called "whips," are a perpetual problem. In the old days, when growing a central-leader tree, those whips were simply headed (cut) at waist height and then a lower tier of scaffold branches would result from buds breaking and shoots growing (feathers) vigorously just below the heading cut. Then some of those would have to be "stripped" off so that a proper leader could form (http://fruitadvisor.info/tfruit/clements/articles/youngtreetraining.htm).

But if a tall-spindle system is being planted, that heading cut is a big no-no, you do not want strong vigorous shoots that form permanent scaffold branches. Unless the nursery tree comes already feathered, it is nice to get numerous smaller branches "breaking" along the length of the leader, starting at approximately knee height and moving up the leader. What typically happens on whips, however, is only the top buds break going a foot down or so from the top of the leader. In addition to ending up with a top-heavy tree, those shoots will flex their apical dominance and further prevent lower buds from breaking. So, intervention is desired on newly planted whip apple trees to get the uniform branching up and down (to knee height) the tree and create the desired tall-spindle form early and going forward.

Several techniques can be used to induce this kind of branching. A common recommendation is to spray the leader with 6-benzyladenine (6-BA) at bud break. Benzyladenine formulations include Promalin and Maxel (Valent) and Exilis and Perlan (Fine Americas). Over the years, BA application has not been particularly successful at inducing branching (http://umassfruitnotes.com/v75n3/a3.pdf). Dormant buds along the leader can also be painted with a high concentration of 6-BA in latex paint, but this must be done before bud break. It is largely successful but can stunt the growth of the resulting shoots (http://umassfruitnotes.com/v79n3/a2.pdf; http://umassfruitnotes.com/v80n1/a2.pdf; http://umassfruitnotes.com/v85n1/a6.pdf). Notching of the leader just above the bud where a branch break is desired can be effective, however, it is time consuming when using a hack-saw blade as has been often recommended. An alternative approach uses a double-edged, anvil-style hand pruner making two opposite side "notches" just above buds in the region where branching is desired (Stefano Musacchi, WSU, personal communication). Some preliminary tests suggested that this might be an effective approach in Massachusetts. So, in 2021 a mini-experiment was established to demonstrate this method of inducing branching on newly planted whip apple trees.

Methodology was quite simple, 30 just-planted whip apple trees were selected at the UMass Cold Spring Orchard in Belchertown, MA. In a random manner, ten of the trees were notched using a double-edge hand pruner (STA-FOR Double Cutting Pruner, https://www.oescoinc.com/hand-tools/hand-pruners/double-cutting-pruner.html) just above each bud in the region where branching was desired, i.e. from approximately knee height then upwards about 18 to 24 inches. Typically, eight buds (plus or minus) per tree were double-notched. This was done just as the buds in the top of the trees were breaking, but the dormant buds that were notched showed little or no growth. Benzyladenine in the form of Promalin per the

Figure 1. Notching just above a dormant bud using a double-bladed anvil style pruner.

Figure 2. Notching resulted in 8.5 feathered branch breaks per tree.

Figure 3. Application of 6-BA resulted in an average of only 1.9 feathered branch breaks per tree.

Figure 4. The untreated control averaged 0.8 feathered branch breaks per tree.

label rate (400 ppm) and directions for promoting branching at bud break was also applied to a similar region of the leader on ten other trees, and ten trees were left alone (the untreated control, UTC).

In mid-June, the number of branch breaks (greater than 2.5 inches in length) on each tree in the region the branching treatments were applied were counted, and the results speak for themself. Notched trees averaged 8.5 "breaks" per tree. Nearly every notched bud broke and grew into a feather. Application of 6-BA way underperformed compared to notching, with only 1.9 breaks per

tree, and the UTC only had an average of 0.8 branches per tree. A statistical analysis was done on the data, and the difference in branching was significant, and the notched treatment resulted in significantly more branching than the 6-BA or UTC treatments, which did not significantly differ from each other.

Clearly, notching using this double-edged anvil-style pruner is effective, and making the notches using the pruner is reasonably quick. Care must be taken, however, to not cut all the way through the trunk or to girdle the tree. Someone suggested angling the pruner a bit to lessen the risk of girdling. For several hundred newly planted trees that are whips it sure beats getting out the 6-BA filled backpack sprayer or the paint mixed up with 6-BA, as notching in this manner is very effective at making branches. You do of course need to have a viable bud where the notch is made, and it is not effective at breaking branches on older "blind" wood without further intervention (http://umassfruitnotes.com/v82n3/a2.pdf). Furthermore, 1st-leaf trees should be planted early, fertilized, and irrigated to get the most out of your notching effort.

Here is a YouTube video about this mini-experiment: https://youtu.be/x2EqTUTBhFc

Effectiveness of the Insecticides Verdepryn and Avaunt at Controlling Plum Curculio in Apple Orchards in Massachusetts and Rhode Island

Jaime C. Piñero, Prabina Regmi, Dorna Saadat, Ajay Giri, Jaelyn Kassoy, and Shawn McIntire
University of Massachusetts Amherst

Heather Faubert
University of Rhode Island

In eastern North America, most apple growers consider plum curculio as one of the most difficult insect pests to control. While there are many insecticides available for plum curculio control, their performance characteristics vary greatly compared to our traditional broad-spectrum chemistries. Conventional insecticides, such as organophosphates (active ingredient: Phosmet, IRC group 1B) work primarily as lethal contact poisons on plum curculio adults in the tree canopy. Imidan, a contact organophosphate, has been used for many years to kill plum curculios at petal fall. Other materials such as Avaunt (active ingredient: Indoxacarb, IRAC group 22) also work primarily by lethal activity, but ingestion is an important means for delivering the poison.

To manage plum curculio and other pests such as codling moth simultaneously, insecticides that contain active ingredients effective against multiple insects are critical. Diamide insecticides such as Exirel (active ingredient: cyantraniliprole, IRAC group 28) have been shown to provide fair to good plum curculio control, but ingestion by plum curculio adults is important for optimal insecticide performance. Verdepryn (active ingredient: Cyclaniliprole, IRAC group 28) is a new insecticide registered for use on several crops including pome fruit, grape, berries, and small fruit. It was registered in late 2019 and available for use starting in 2020. In pome fruit, Verdepryn is registered for control of a variety of insects, including lepidopteran pests, plum curculio, and for suppression of thrips, apple maggot, and stink bugs. More information on other insects and recommended use for certain species can be found on the label. Limited information is available on the effectiveness of this material at controlling plum curculio, particularly in New England apple orchards.

Here, we compared the performance of Verdepryn against that of Avaunt at controlling plum curculio at petal fall at the UMass Cold Spring Orchard. In addition, we report the effectiveness of Verdepryn applied against this pest in one commercial apple orchard in Rhode Island.

Materials & Methods

Study sites. This study took place at the University of Massachusetts Cold Spring Orchard (CSO), in Belchertown, MA, from 17-28 May, 2021. In advance of the insecticide sprays, multiple apple blocks comprising largely the cultivars McIntosh, Paula Red, Empire, Fuji, Golden Delicious, and Cortland, among others, were randomly assigned treatments using colored ribbon. In all, 22.8 acres were sprayed (14.9 acres received Avaunt [rate: 6 oz/A], and 7.9 acres received Verdepryn [rate: 11 oz/A). All blocks were sprayed on 17 May, 2021. The insecticide applications were made at a tractor speed of 2.5 mph at 100 gallons per acre. The block with alternate applications of Verdepryn and Avaunt were made spraying half of the rows so that both materials were represented similarly for habitat facing perimeter-row trees. Except for one block that received split-row applications of Avaunt and Verdepryn, blocks received a single material.

A second study took place at Rocky Brook Or-

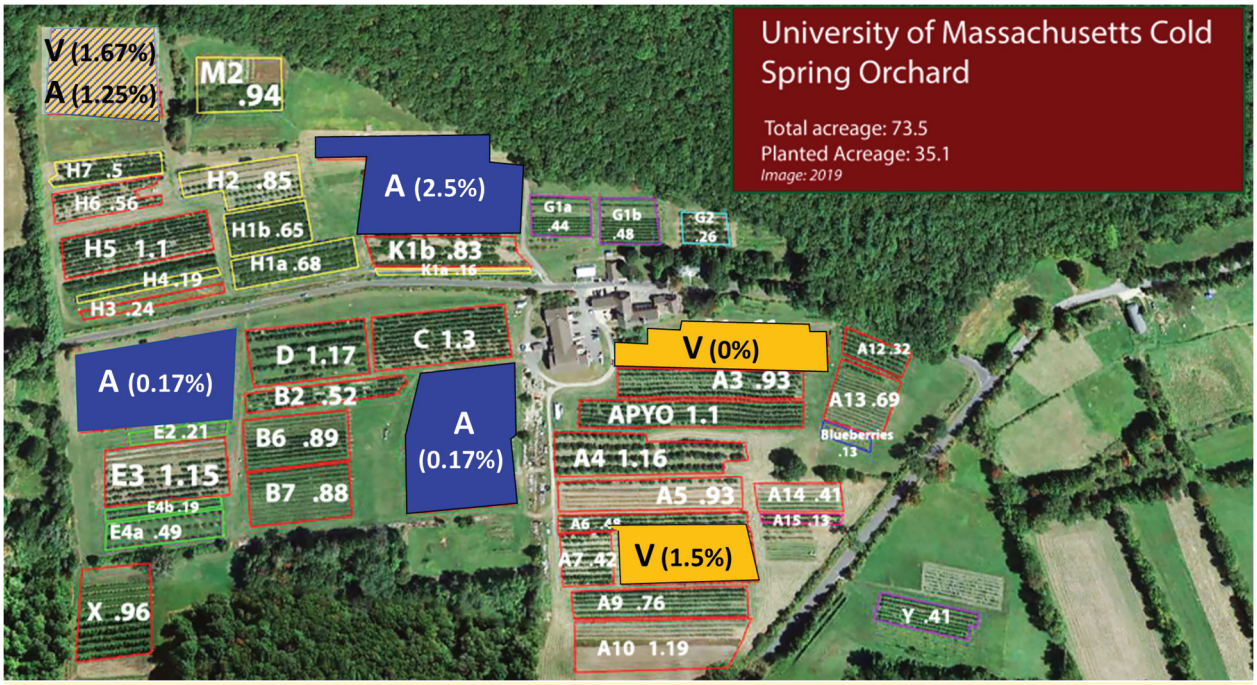

Figure 1. Partial view of the UMass Cold Spring Orchard showing the six sampled blocks. Blue boxes: Avaunt application. Yellow boxes: Verdepryn application. One block (shown on the top left using alternating diagonal stripes) received a split-row application of each material. Numbers in parenthesis indicate percent fruit injury by plum curculio in that block. Most of the other blocks were sprayed with either, Verdepryn or Avaunt, but they were not included in the fruit sampling,

chard in Middletown, RI. On May 22, 2021, Verdepryn was applied (rate: 8.5 oz/A) to apple trees (4.5 acres) at petal fall, targeting plum curculio. Pears (0.5 acres) were also sprayed against plum curculio, but infestation data were not recorded. Insecticide application was done using grower practices.

Fruit sampling. At CSO, non-destructive fruit sampling was conducted on May 28. For the sampling, we selected six representative blocks (2 for Verdepryn-only, 3 for Avaunt-only, and 1 for the split-row application of Verdepryn and Avaunt). Figure 1 shows the sampled blocks. A group of four people who received training on plum curculio injury assessment inspected 30 fruits for each of 20 trees throughout the block, for a total of 600 fruit sampled per block. In all 4,200 individual fruits were inspected for plum curculio damage in the six blocks. Results are presented as the percentage of sampled fruit that had plum curculio injury.

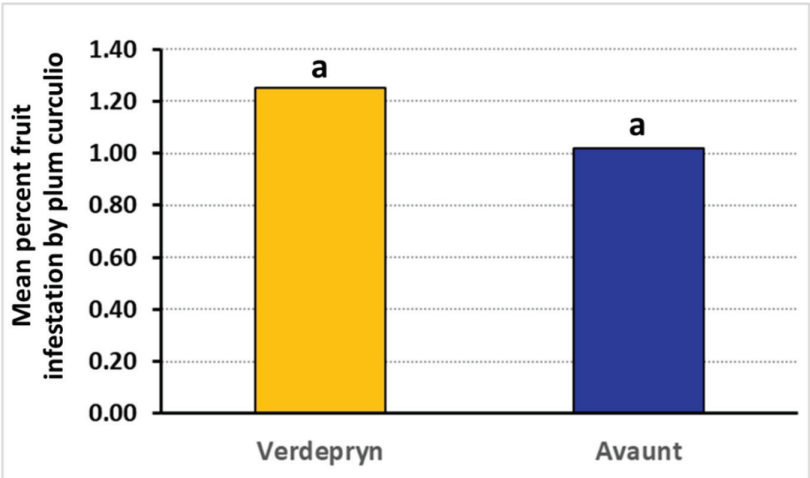

Figure 2. Across six sampled blocks at the UMass CSO, average level of plum curculio injury to sampled fruit according to insecticide type. Same letters above bars denote lack of statistically significant differences between treatments at odds of 19:1.

At Rocky Brook Orchard, fruit sampling was conducted on June 1, 2021. Because this orchard has over

80 apple cultivars, we focused on early- and mid-season ripening cultivars. For each of 25 trees, 30 fruits per tree were visually inspected for plum curculio injury. In all, 750 fruits were visually inspected.

Results

Cold Spring Orchard. Figure 1 shows the level of plum curculio injury on each of the six blocks that were sampled. Block-wide infestation levels ranged from 0% to 2.5%. Overall, the average level of injury recorded in blocks receiving a single application of Verdepryn (1.25% on average) at petal fall did not differ significantly from that recorded in blocks that received Avaunt (1.02% on average) (Figure 2). In the block that received split-row applications of either product (box with alternating diagonal stripes in Figure 1), sampled apple fruit in the area sprayed with Verdepryn received 1.67% injury whereas the level of injury by plum curculio recorded in the area that received Avaunt was 1.25%.

Rocky Brook Orchard. At this orchard, only one material (Verdepryn) was applied against plum curculio at petal fall. The level of injury recorded in the June 1 sampling was 0.26%, which means that nearly three apples per 1,000 showed plum curculio injury.

Conclusions

The results from this study indicated that Verdepryn is as effective at controlling plum curculio as Avaunt, when applied at petal fall. This study involved a single petal fall insecticide application instead of a season-long management program for plum curculio. Since according to the label the maximum number of applications of Verdepryn allowed is 3, then growers could accommodate one spray of Verdepryn against plum curculio and then the product would still be available against codling moth or other pests.

Acknowledgments

We thank Greg Ostheimer for allowing us to survey plum curculio at Rocky Brook Orchard. Dr. Eric Tedford (SummitAgro, USA) provided Verdepryn for the evaluations. Funding for this research was provided by the UMass Stockbridge School of Agriculture. We also gratefully acknowledge the support of the Center for Agriculture, Food, & the Environment Summer Scholars Program.

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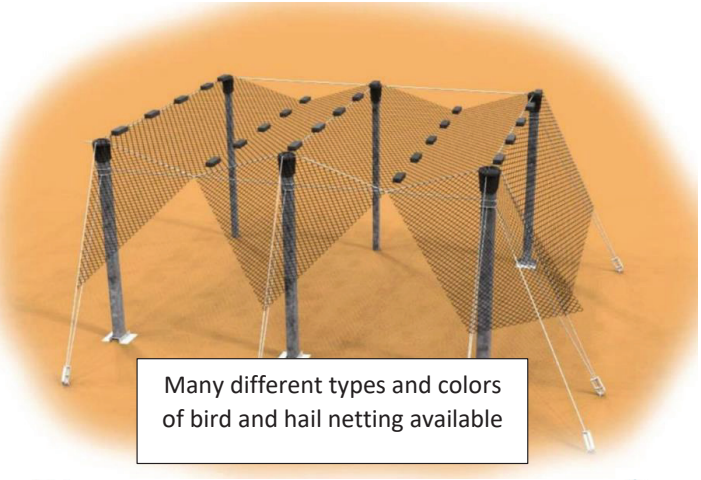

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Breaking the Biennial Bearing Cycle in Apple with Arrange™ PGR

Win Cowgill
Professor Emeritus Rutgers University, Win Enterprises International, LLC

Daniel J. Donahue
CCE Extension Associate-Tree Fruit Specialist, Cornell University

A major apple problem in commercial apple production worldwide is biennial or alternate bearing. Many of our commercial apple varieties are prone to biennial bearing, but some are worse than others. Fuji is one of the worst, and Honeycrisp can be as well. Control of biennial bearing can be very challenging and certainly is one of the most difficult tasks apple growers face every year. Growers must use a number of management techniques to regulate fruiting and flowering to increase flower bud formation. Pruning, chemical thinning with PGR's, rootstock selection, and summer return bloom programs (Cowgill, Autio, 2016) with PGR's all can be used. We have gotten better at these practices with our precision thinning programs (Francescatto and Robinson, 2016) and (Schwallier, 2015). There is another approach, however, that has been studied for over 50 years that will provide a complementary addition to the other programs for varieties that that are very biennial. That is the ability of gibberellins to inhibit flowering in pome fruit (Green, 2000). In 1981, Marino and Greene (1981) detailed the involvement of gibberellins in the biennial bearing of Early McIntosh apples. Schmidt (2006) did multiple experiments looking at cropload and flower manipulation with gibberellins and other PGR's on apple. Suppression of apple bloom with gibberellin sprays was shown by Unrath and Whitworth (1991).

There are many different commercially available gibberellins labeled for apples that result in better fruit quality (reduced russeting) and enhanced fruit set after a freeze at bloom. The historical work has shown that some gibberellins applied in the off year can reduce bloom in the on year, thereby reducing the biennial bearing cycle. Green (1992) found both GA_4 and GA_7 inhibited return bloom on Redspur Delicious, although GA_7 inhibited flowering more severely. Four sprays of GA_3 or three of GA_{4+7} at 250 mg·L–1 essentially eliminated flowering in Gala, whereas it was not quite enough on Pink Lady. Davis (2002) observed that GA_{4+7} more effectively suppressed flowering than GA_3 on Ramey York in Blacksburg, Virginia.

There are many different formulations of GA with different concentrations of the active ingredients. Personal communication with Jim Scrugss, Fine Americas, Inc., indicates that most commercial formulations of gibberellins for apple contain various concentrations

Figure 1. Treatments applied to single trees with a Solo 451 sprayer.

of GA_4 and GA_7. What varies is the ratio of these two gibberellins in the commercial product. For instance, GA_4 has a minimal effect on return bloom while GA_7 is significantly more active according to Scruggs.

Arrange™ Trial New Jersey

Arrange™, plant growth regulator for use on apple was labeled in 2020 by Fine Americas, Inc. "to mitigate the biennial bearing cycle in apple varieties prone to producing crops in a biennial cycle". When applied to trees in the "off" bearing year, when fruit load is low, Arrange can be used to reduce the return bloom of the apple trees in the following "on" bearing year when fruit set/load would normally be heavier.

In 2020 and 2021 multiple trials in New York and New Jersey were conducted to confirm the efficacy of Arrange to modify biennial bearing on apple in commercial blocks. This article includes brief results from the 2020 trial at Wightman Farms, Morristown, NJ. Two varieties were selected, Crispen and Fuji planted to a tall spindle system, on full dwarfing rootstock. Trees were 7-years old and approximately 11 feet tall for Crispen and 9 feet tall for Fuji. The study was set up as a completely randomized trial with 10 single-tree replications with no buffer tree on each side of the treatment tree.

Treatments were applied June 13, 2020 at 100 gallons per acre tree row volume with a backpack Solo 451 air powered sprayer (Figure 1). Only one application was applied. The label allows for multiple applications, but 100ppm total. Both Arrange treatments were applied with Regulaid surfactant at 1 quart/100 gallons. Treatments were as follows:

1) Untreated control
2) 100 ppm - label rate (1 gallon/100gallons)
3) 200 ppm - 2x Label rate (2 gallons/100 gallons)

In May of 2021, bloom was evaluated for each tree. The total number of flowering spurs was counted, and total number of resting spurs was counted. The binomial data set was analyzed using JMP software ver. 14.0 from SAS, Fit Y by X Platform, Analysis of Means of Proportions procedure, alpha = 0.05.

For Fuji, both treatments significantly reduced flowering (Table 1). One hundred ppm and 200 ppm reduced return bloom to 60% and 47% of spurs, respectively. For Crispen, both treatments also significantly reduced flowering, but the 100 ppm and 200 ppm were not significantly different from each other (Table 1).

Table 1. The effects of Arrange application in 2020 on bloom in 2021 (percent of spurs flowering).

Application rate (ppm)	Fuji	Mutsu
0	75	74
100	60	55
200	47	47

Reductions were 55% and 47% for 100 ppm and 200 ppm, respectively.

These reductions in bloom should help break the biennial bearing cycle in these trees.

Future and Ongoing Research

For the past three years we have been looking at GA_7 as Arrange for reducing flower bud formation on apple in the nursery and in first-year established apple orchards. While this is not a labeled use yet, the data are indicating that this may be an efficacious way that nursery apples can be treated to reduce or eliminate bloom so there is not a fireblight issue on the subsequent blooming of this newly planted trees. This has been a significant issue on newly planted high density apple orchards.

More on this line of research will be forthcoming as data is collected.

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Update on Pesticide Combinations That Can cause Phytotoxicity

Win Cowgill
Professor Emeritus, Rutgers University, Win Enterprises International, LLC.

The economic impact of phototoxicity (damage to fruit and or leaves) can have a tremendous financial impact on farm finances. The economic impact to perennial crop like wine grapes can be even larger. Phytotoxic effects can show a wide range of symptoms; however, a key diagnostic feature is uniformity. The pattern of symptom development typically follows the application method. For example, an eight-row boom sprayer would give a distinctly different pattern than spot applications of an herbicide.

We have identified a few key causes of phytotoxicity, and new ones continue to pop up. One of the biggest problems is a pesticide may be labeled and do an excellent job on one species, but cause damage on a second species. The challenge is that most growers grow multiple crops.

Often, this potential damage is not noted on the label!

Vivando Fungicide -The newest Phytotoxicity Issue

Vivando Fungicide, a newer fungicide from BASF, is labeled on grapes. It turns out that Vivando can cause phytotoxicity on apple leaves and fruit if the same tank is used following a grape application. Note that the Vivando label has no warning about apple sensitivity, and apples are not on the label. For a few years, a NJ grower noticed spots on his apple leaves and fruit but only on a few cultivars, specifically Macoun, Snow Sweet, and Bramley. After searching the BASF website, maker of Vivando Fungicide, he

Figure 1. Vivando foliar injury on Macoun apple, Hunterdon County, NJ.

Figure 2. Vivando foliar injury on Snow Sweet apple, Hunterdon County, NJ.

found a 2015 Product Guide for Apple Safety warning against damage to apples if Vivando was applied.

This grower applied Vivando to his grapes, only a small amount of residue was left in the empty grape spray tank before he mixed a tank with different pesticides for apple. The little bit of residue was enough to cause damage to his Macouns, Snow Sweets (leaf curl), and Bramleys. On Bramley it scarred the fruit at a concentration of less than 1 ppm!

It appears that a residue of a few parts per million of Vivando can cause injury to apple (<1.0 to 25ppm). Since you cannot clean residues and eliminate them perfectly in a commercial airblast sprayer, then Vivando fungicide does not belong on a farm growing apples.

Sources:
https://agriculture.basf.us/content/dam/cxm/agriculture/crop-protection/products/documents/BASF_ProductGuide_Vivando_AppleSafety_medres.pdf

Review of a Few Tree-fruit Pesticides That Can Cause Phytotoxicity on Apple

Phytotoxicity can show up as spotting on leaves and fruit, unusual growth patterns, blighting leaves or flowers, stunted growth, reduced root growth, as well as complete plant death. Symptoms often develop within a few days of an application although in some cases phytotoxicity may take much longer to develop. We have seen Roundup injury express one to two years after the application was made (in apple, it is absorbed by the plant, stored in the roots,

Figure 3. Vivando foliar injury to Bramley Apple, Hunterdon County, NJ.

Figure 4. Vivando fruit injury to Bramley Apple, Hunterdon County, NJ.

and travels up to the foliage the following spring, where it is expressed as injury to the leaves). It is essential to properly diagnose phytotoxicity and make sure that the same mistakes are not made twice. The most telling symptom of phytotoxicity is a uniform distribution. For example, is the entire field affected, is damage limited to the end of the row, or is there any evidence of a uniform pattern? Once this has been established research should be conducted to determine and confirm the cause.

There are various factors that can sometimes mimic phytotoxicity. For example, a frost event can cause uniform damage to one part of a field or just the bottom halves of fruit trees. Soil pH, salt injury or fertilizer burns are other possible factors that might mimic phytotoxicity. Information on the climatic conditions and soil factors are critical in making a diagnosis.

Types of Pesticides

Pesticides are toxins that kill or inhibit the target organism. They are generally considered selective toxins and when used as prescribed by the label will not harm the crop. It is important to note that some pesticides (such as captan and chlorothalonil) are biocidal and will kill any cell into which they gain entry (especially on grape). They are selective because they are formulated so that the target organisms will ingest them, and non-target organisms will not. These surface acting pesticides do not enter the plant cell. Other pesticides target a certain biochemical pathway that is unique to the target organism(s). Often these types of pesticides maybe systemic and be translocated in the plant tissues.

Causes of Phytotoxicity

1. **Direct toxicity.** Certain pesticides are simply toxic to a particular crop species or variety. When a pesticide is applied to the crop with the goal of controlling a specific pest, weed or pathogen phytotoxic symptoms develop on the entire treated area. A classic example of this scenario is with the fungicide azoxystrobin (Abound, Quadris) on apple (see the example writeup). In grapes, Concords as well as some other varieties are sensitive to a variety of pesticides including Revus, Pristine, Flint, and sulfur. Many herbicides are selective in toxicity and may cause direct injury to a sensitive crop type.
2. **Overdose.** Pesticides are formulated to be applied at a specific rate or rate range. Overdosing can arise from poor sprayer calibration, lack of uniformity or inaccurate rate calculations. In all cases, overdose levels may be large (i.e. 10 fold) and a variety of problems including phytotoxicity as well as excessive residues may develop. Sprayer calibration can be difficult with airblast sprayers that may reach one to many rows depending on wind conditions. Growers should calibrate and spray at the minimum row interval that is practical. Even if the spray can reach further, by spraying at a tight interval insures a more uniform and accurate application. Non-uniformity can be the result of overlapping sprays, poor guidance systems or calibration for a larger area than the sprayer is capable of reaching in a single swath. Systemic materials such as Ridomil will cause burning along the leaf margins when too high a rate is applied. This symptom develops because the material is translocated with the flow of water

in a plant. Thus, the chemical is translocated and concentrated in the leaf margins and if an excessive rate is used chlorosis and burning will develop.

3. **Mixtures.** Most pesticides are marketed as a formulated product. For example, there are granular formulations, wettable powders, and emulsifiable concentrates to name only a few. These formulations are specifically tailored for maximizing the effect of the individual pesticide. A convenient and economical method for controlling several pest problems at once is through the use of pesticide mixtures. Fungicides and insecticides are commonly used in combination for disease and insect control. Many problems can arise from inappropriate use of mixtures. Chemicals that are physically incompatible form an insoluble precipitate that clogs nozzles and sprayer lines. Other mixtures may be phytotoxic and result in a crop loss. Mixing formulations of diazinon or Danitol with Captan or Captec have caused crop injury in the past. Therefore, diazinon and Captan formulations should **not** be tank-mixed. This type of phytotoxicity results from either a direct interaction of the active ingredients or an interaction of the "inert" ingredients in one formulation that enhances the toxicity of the other one, e.g. Syllit 65WG should not be combined with dormant oil, sulfur, chlorpyrifos or foliar nutirents.

A third type of incompatibility arises when one component of the mixture reduces efficacy of the other component.

When Using Pesticide Mixtures, There Are Several Guidelines to Follow

1. Read the label, and follow the manufacturer directions. A section specifically addressing compatibility is usually included on the label. If you are in doubt, contact the manufacturer or a technical representative.
2. Obtain a compatibility chart, and use it as a guideline only. Compatibility charts are frequently out of date, because new pesticide formulations can alter compatibility. However, they provide useful baseline information.
3. Use a jar test to determine physical compatibility. Jar tests are conducted by mixing chemicals at approximately the same rate as specified on the labels. The volumes are scaled down to fit in a small (1 pint – 1 quart) container. Results are evaluated by observing the mixture for reactions such as formation of larger particles, the formation of layers, or other changes that result in the formation of a precipitate (i.e. sludge at the bottom of the container).
4. Chemicals that are physically compatible may be phytotoxic**.** Note: Captan formulations and Oil are the most obvious, all EC formulations (e.g. Diazinon, Danitol and some fungicides) have oil and should not be used on grapes (See the Example). Therefore, mixtures of new chemicals should always be tested on a small number of plants before being sprayed on a larger area. Phytotoxicity may appear as wilting, spotting, dieback, or other abnormalities in plant growth. The appearance of phytotoxicity may be environmentally controlled. For example, high temperatures may cause more severe expression of phytotoxicity. Environmental variables can play a big role in causing mixtures as well as single component sprays to perform not as predicted.
5. Use of spray additives, such as spreaders, stickers, penetrants, or activators, can greatly complicate chemical compatibility in mixtures. Unless recommended by the manufacturer, these additives should be avoided.
6. For aircraft sprays, apply at least 5 gal/A of spray mix. Use a jar test to check for compatibility of pesticides.

Mixtures provide an economical and efficient method for applying different classes of pesticides. Mixtures can provide enhanced activity through

synergism and in some cases reduce the chance of resistance developing in the target population. Some chemical companies market pesticides premixed. Thus, appropriate use of mixtures **requires** preliminary research to determine the compatibility.

Incompatible spray schedules. A related topic to mixtures is incompatible spray schedules. In this case use one product such as a crop oil followed by another product such as sulfur or captan will cause phytoxicity. The pesticide labels will generally give a recommended interval to avoid problems.

Excessive concentrations. If a pesticide is applied at a specific rate to an agricultural field it must be applied in a specific volume of water. Some pesticides are safe to the crop if applied at a high enough dilution. Also, the pH of the water used can affect both pesticide activity and phytotoxicity. An example of this situation occurred with some phosphite fungicides. These materials were found to be phytotoxic when used in less than 50gallons/acre of water if the pH of the water was less than 5.5.

Climate and Phytotoxicity. Pesticide applications should be made under "ideal" climate conditions. However, this is often impractical. Understanding the implications of various climate conditions can help minimize possible negative effects.

Application during windy periods can lead to drift. This is particularly important when applying herbicides near sensitive crops. For example, Roundup applied to Roundup resistant crops may drift to sensitive neighbors. Also, herbicides applied to the ground may be carried into the sensitive canopy during windy conditions.

Plants growing in cool overcast seasons are often more sensitive to phytotoxicity. It is likely that these plants have a more easily penetrated cuticle and are more sensitive to the biocidal chemicals.

Temperature can greatly affect pesticide related phytotoxicity. Compounds such as sulfur, chlorothalonil and captan can become phytotoxic at high temperatures. A good rule of thumb is to avoid spraying when temperatures exceed 85F.

Examples of Phytoxicity

The Captan Conundrum: Scab Control vs. Phytotoxicity

Dave Rosenberger, Professor Emeritus, Cornell

Captan is a cornerstone fungicide for apples because it is very effective against apple scab and also controls summer fruit rots. Captan has long been noted for its ability to prevent scab on fruit even when scab control on leaves is less than perfect. In fungicide tests in replicated plots where we purposely used lower than recommended rates, Captan 50W at 3 lb./A has usually provided better control of apple scab than mancozeb fungicides applied at the same rate.

Fungi do not become resistant to captan because it blocks multiple biochemical pathways (i.e., it is a multi-site inhibitor). Resistance to captan can occur only if fungi develop simultaneous mutations for all of the blocked pathways, something that has not happened in the 60 years since captan was introduced.

Captan kills spores that it contacts whereas many of our newer fungicides kill fungi or arrest fungal growth only after germ tubes emerge from the spores. As a result, when captan is applied in combinations with other fungicides in protectant sprays, captan usually does 90 to 99% of the work by killing spores on contact, thereby reducing selection pressure for fungicide resistance to the other product in the tank mix. We use tank mixes with other fungicides (dodine, benzimidazoles, DMIs, strobilurins, SDHIs) to expand the spectrum of disease control and/or to control/suppress the small amount of scab that may have escaped control from the last spray. Captan does not control powdery mildew or rust diseases, so tank mixes are needed to control those diseases even when captan alone might suffice for controlling apple scab.

Unfortunately, captan also has a dark side: it is toxic to plant cells if it penetrates into leaf or fruit tissue. Spray oil and other spray adjuvants that act as penetrants allow captan to move through the protective wax cuticle on leaf surfaces. When that

occurs, we see captan-induced leaf spotting, usually on the two or three leaves on each terminal that were just unfolding at the time trees were sprayed. It takes time for cuticular waxes to develop on new leaves, so young unfolding leaves are the most susceptible to spray injury. The leaf cells directly killed or injured by captan provide entry sites for other leaf spotting fungi such as *Phomopsis, Alternaria,* and *Botryosphaeria* than can enlarge the spots. It may take five or 10 days for the injury to become visible, and by that time the injured leaves may be 5 or 6 nodes below the growing point on terminal shoots.

Captan injury on apples usually appears during the three weeks after petal fall because during that time period terminal shoots are growing very rapidly (i.e., producing lots of new leaves), and spray mixtures used at petal fall and in first and second cover sprays commonly include insecticides, growth regulators, foliar nutrients, and spray adjuvants. Captan applied alone almost never causes leaf spotting on apples. Rather, it is the other products in the tank that sometimes enhance captan uptake and trigger the resultant phytotoxicity. Increasing the number of products that are included in a tank mixture increases the probabilities that the mixture will enhance captan absorption and result in injury to leaves.

Sensitivity of Apple Cultivars to Azoxystrobin Fungicide

Norman Lalancette, Win Cowgill, Jeremy Compton, and Kathleen Foster

Three Strobilurin fungicides became labeled for growers in the late 1990's: azoxystrobin (Abound), kresoxim-methyl (Sovran), and trifloxystrobin (Flint). With respect to tree-fruit crops, Abound is available for use on stone fruit, while both Sovran and Flint are labeled for pome fruit; all three are registered for use on grape as well as various other crops. Each of the three registered strobilurins has some level of phytotoxicity to another crop. For azoxystrobin, certain apple cultivars –particularly McIntosh – have been found to be particularly sensitive. This phenomenon complicates usage by orchardists who have both stone and pome fruit. Many growers in both NJ and Massachusetts have both. Research in NJ in 1999-2000 evaluated 96 strains and variety of apple to test sensitivity of apple to azoxystrobin. Tables 2, 3 show the results.

Table 2. Apple cultivars and strains moderately sensitive to azoxystrobin fungicide

Braeburn	Slight leaf curl, possible stunting; No necrosis or drop
Luster Elster	2% leaf necrosis / browning
Red Delicious, Dulcet	2% leaf necrosis / browning
Shamrock	10% stippling
Suncrisp	20% basil leaf drop on 2-year wood; uninjured 1-year wood; browned fruit
Sunrise	10% leaf drop; 10% scorch

Highly sensitive cultivars. A total of 33 cultivars and strains were found to be highly sensitive to azoxystrobin sprayed at the indicated concentration. Leaves on treated shoots initially became necrotic (uniformly brown), with 100% defoliation eventually occurring on many of the cultivars. However, treated lateral buds on shoots remained green and the majority of the terminal buds began to grow and produce new foliage later in the summer.

Table 3. Apple cultivars and strains highly sensitive to azoxystrobin fungicide

Akane	Gala, Stark Ultra Red	Northwest Greening
Britemac	Gravenstein	Pink Lady
Cortland	Keepsake	Raritan
Cox Orange Pippin	Liberty	Red Cort
Fameuse	Macoun	Redfree
Gala	McIntosh, Millers	Red Haralson
Gala, Royal	McIntosh, Rodgers Red	Spartan
Gala, Imperial	McShay	Spire, Scarlett
Gala, Lydia's Red	Mollies Delicious	Vista Bella
Gala, Scarlet	Northern Lights	Wealthy
Gala, Stark Galaxy	Northern Spy	William's Pride

Wine Grape Phytotoxicity to Captan 80WDG + Danitol 2.4EC in NJ

Win Cowgill

At the Rutgers Snyder Farm in 2010, Captan and Danitol 2.4 EC were applied twice in midseason on standard IPM-based pest control program. The right weather conditions, warm 80's and humid, created the perfect conditions for the oil in the Danitol to pull the Captan into the plants, killing some of the more sensitive grape cultivars in the variety trial. No warning is found on either label, but they should not be combined together on wine grapes.

Literature Cited

2013, 2019 Commercial Grape Pest Control Information for New Jersey- E283. Dan Ward, Brad Majek, Peter Oudemans, Douglas Pfeiffer. http://njaes.rutgers.edu/pubs/publication.asp?pid=e283

New York and Pennsylvania Pest Management Guidelines for Grapes. http://ipmguidelines.org/grapes/

Wine Grape Production Guide for Eastern North America. Tony Wolfe https://www.amazon.com/Grape-Production-Guide-Eastern-America/dp/1933395125

Painless and Efficient Maturity Testing

Win Cowgill
Professor Emeritus Rutgers, Win Enterprises International, LLC
Jon Clements
Extension Tree Fruit Educator, University of Massachusetts

Our observation has been that few growers utilize the Starch Index (SI) method of determining harvest maturity. Perhaps SI testing is perceived as time consuming and difficult to properly judge. We contend, however, that SI testing is the best and easiest indicator of apple maturity that a grower can use to plan their harvest and storage regimes.

Why is it important to perform SI testing? First, as mentioned, the SI method is probably the best way to judge fruit maturity without expensive equipment. The Sl technique, wherein the starch content is visualized, is correlated with ethylene evolution. In fact, ethylene synthesis occurs as fruit ripens. Therefore, the SI index is an inexpensive way to assess the degree to which fruit has converted starch to sugar and is indicative of the onset and progress of ethylene production.

Secondly, because SI is a reliable indicator of relative fruit maturity, SI testing can help you determine if harvested fruit should be placed in early CA, late CA, or regular cold storage. Remember that, as a rule, fruit with SI readings of 3-4 are suitable for late CA, apples measuring 4-6 on the SI scale are best for early CA, and any fruit reading 6 or above should be placed in regular cold storage or marketed immediately. Of course, reliability in using the SI method for determining apple maturity is predicated on good sampling techniques, i.e.; looking at fruit that has sufficient size and color. Or, in other words, sample apples that you expect are approaching harvest readiness. [Note: Apples going into late CA (available in April-June, etc.) should not average less than 16 lbs. flesh firmness, except for Honeycrisp.]

The postharvest physiologists at Cornell University have developed a universally accepted chart that is useful for all varieties. Cornell has an excellent publication available to help you use the starch-iodine test and to develop an apple maturity program. The publication also contains a laminated starch iodine chart to aid in interpreting the tests. I strongly suggest that anyone seriously interested in harvesting high quality apples with good storage potential download a copy of this publication, 'Predicting Harvest Date Windows for Apples (1992)' Information Bulletin 221 -- http://ecommons.library.cornell.edu/handle/1813/3299

Full-color plates show how to use and interpret the starch-iodine test for determining maturity and the best harvest dates for quality, especially important for apples going into storage. It covers McIntosh, Cortland, Empire, Delicious, Mutsu/Crispin, and Idared; dates for other varieties can be interpreted from the information presented. The cost of the publication is $5.50 and can be ordered from Cornell University by calling 607-255-2080 and using a credit card to pay for the pub or by ordering online at http://ecommons.library.cornell.edu/handle/1813/3299

Having tested tens of thousands of apples over the years, per numerous experimental protocols, we can now suggest a simple, quick, and efficient method for evaluating orchard by orchard or block by block SI apple samples. Here is our quick and simple testing technique:

- Equipment consists of a one quart hand-operated spray bottle filled with SI solution, a pocketknife, and a Starch Index chart. It's most important to just use the chart and begin sampling and testing the fruit two weeks before anticipated harvest to get a baseline on the maturity.
- The procedure is simple -- pick a sample of apples that appear ready to harvest, based on size, color, days after full bloom, and taste. Spray the SI solution on longitudinally halved fruit, wait one to one and one-half minutes, and make your readings based on the SI chart. The whole process is portable, quick, simple, and saves Sl solution compared to dipping individual apple in a solution filled pan.

- It is important to keep good records on your maturity determinations by cultivar and block. You will start to build a good database of harvest maturity information for your orchard.

Although the SI is a reliable gauge of many cultivars, such as McIntosh, Empire, Jonathan, Delicious, Golden Delicious, and Macoun, some cultivars do not work as well to the SI test. Examples include Gala, Honeycrisp, and Fuji, where SI readings do not correlate well with maturity, and maturity of these cultivars should be gauged using background color, soluble solids content, and flesh firmness.

Background color is a very good maturity indicator on Gala and will provide the grower with an accurate maturity gauge. Red color, flesh firmness and soluble solids are not as reliable an indicator of maturity as is background color on this cultivar. Fruit should be harvested for optimum long-term storage quality when the background color of the fruit is changing from a green to yellow color. After that, the background color changes from yellow to cream. It is at this stage that the fruit is ready for immediate sales or short-term storage. Galas will require multiple pickings for optimum fruit quality. Background color is also one of the best indicators of maturity for Fuji cultivars.

Here are some additional resources on fruit maturity testing and for purchasing/making supplies for doing the SI test, including SI Test solution and charts. Also, contact Win Cowgill or Jon Clements if you have further questions or need more information.

How to prepare Starch Iodine test solution from the Ontario Ministry of Agriculture

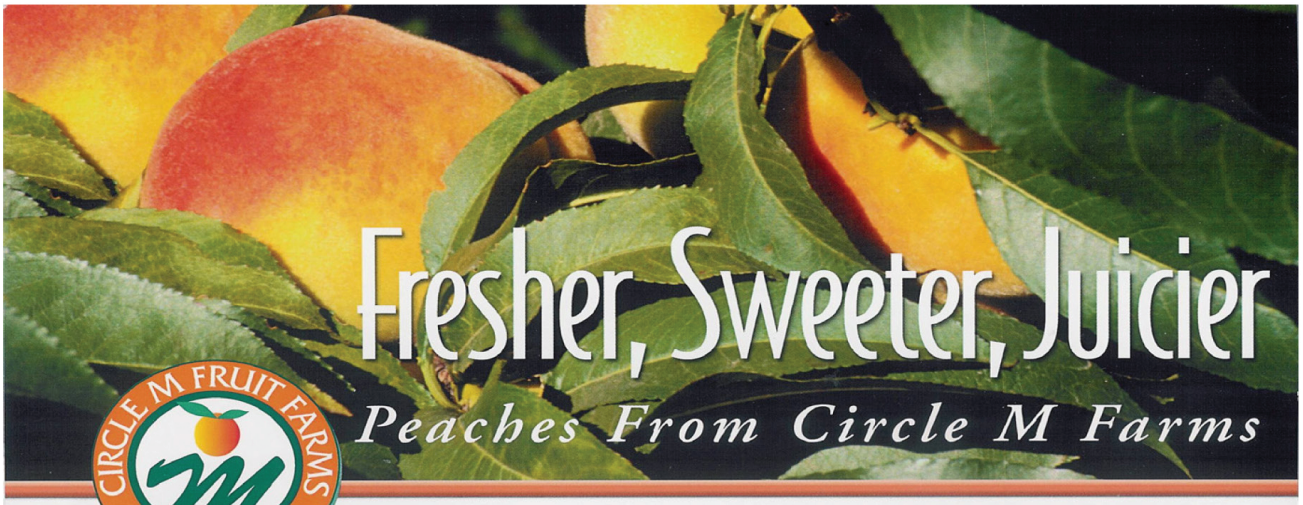
The Ontario Ministry of Agriculture, Food, and Rural Affairs, has two publications on using the SI test, including directions for making the solution and charts for McIntosh, Delicious, Empire, Idared, and Spartan. For the complete Ontario Fact Sheet see http://www.omafra.gov.on.ca/english/crops/facts/00-027.htm#prep

From the Ontario publications: Always use a freshly prepared solution at the beginning of every season. This solution is sensitive to light and should be stored in a dark container. A dark-colored bottle or a glass jar wrapped in aluminum foil will serve the purpose. Chemicals needed for this test are potassium iodide and iodine crystals. A pharmacist or a chemist can use the following recipe to make up the iodine solution. Dissolve 8.8 grams of potassium iodide in approximately 30 mL of warm water. Gently stir the solution until potassium iodide is properly dissolved. Add 2.2 grams of iodine crystals. Shake the mixture until the crystals are thoroughly dissolved. Dilute this mixture with water to make 1.0 L of test solution. Mix them well.

Purchasing Starch Iodine Solution

We have not found a source of pre-mixed iodine solution. Potassium iodide and Iodine crystals can be purchased from Fisher Scientific https://www.fishersci.com/us/en/home.html

Updated August 30, 2021



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